# Computer Assisted
# Environmental Justice Index Methodology

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# Environmental Justice

## A. Introduction

**Environmental Justice refers to the pledge or assurance that no population will endure a disproportionate share of the country's pollution. Evidence has been presented that minority and low income communities are exposed to more environmental pollutants than the general population.[1] A modification of the Region 6 Human Health Risk Index (HRI) formula[2] is used to define and prioritize specific sites as to their potential for environmental justice concerns. The HRI-Justice methodology defines justice criteria, applies basic principles of science, and enables environmental managers to use program specific data to identify communities of most concern.**

The Human Health Risk Index (HRI) enables users to select specific HRI subfactors and perform special regulatory, health, and social-economic analyses. These special applications include environmental justice studies, enforcement targeting analyses, environmental impact studies, and pollution prevention project assessments.

The Environmental Justice chapter describes how a modification of the HRI can evaluate and rank environmental justice concerns around commercial hazardous waste sites. This HRI-justice example uses Geographic Information System (GIS) maps, census demographic data and the HRI method to mathematically rank individual sites. The example's extensive use of GIS maps is for demonstration purposes only. Justice information can be demonstrated using HRI criteria and rankings alone. The method described is automated in GIS and currently analyzes 50 square mile and one square mile geographic areas (communities). The method also has an automated mapping facility. Examples of other special applications in this document are: enforcement targeting and facility permitting.

The Environmental Justice Formula is derived from the Human Health Risk Index (HRI)[2] and is consistent with the approach used in all risk based algorithms: **Exposure multiplied by Hazard equals Risk.**

Human Health Risk Index (HRI) = Exposure X Hazard

The Potential Environmental Justice Index (EJ) defines "exposure" as the population exposed and assumes the <u>total</u> population of a study area is impacted by environmental justice factors. In the HRI, hazard has two components: Degree of Impact (DI) and Degree of Vulnerability (DV). DI is a chemical specific parameter. Inclusion of this factor requires chemical exposure and toxicity information. For the justice formula, Degree of Impact (DI) is not calculated. Potential risk from chemical exposure can be calculated separately (Chapter II, Enforcement Targeting). Degree of Vulnerability is calculated for EJ and includes two criteria: a community's percent minority representation and percent economically stressed households. These EJ methodology criteria (population, percent minority, and percent economically stressed households in the study area) become the "analytical definition" for environmental justice. Each of these parameters are ranked to facilitate the mathematical prioritization process.

Sites are evaluated using an environmental justice formula and ranked on a scale of 0 to 100. Although higher scores can indicate greater potential justice concern, the population density, percent minority population, and percent of economically depressed household data are the more important

analytical factors. When evaluated independently, they often provide greater insight to the potential environmental justice concerns and can be used alone to rank sites (i.e., sites ranked on percent minority or economic status, or the combination of these two factors). The methodology user should realize that even an index ranking of zero can have significant EJ concerns. For example, an unpopulated area will rank a zero, but if owned by minority and/or low income groups, the site may have significant EJ importance.
Environmental Justice Formula:

Environmental Justice Index (EJ) = Exposure X Hazard

(PE/PC X POP) X (DI X DV)

where:

PE = Population Exposed

PC = Population in Community

PE/PC = 1 (assumes total population is effected)

POP = Population Density Ranking (0 - 4)

DI = Degree of Impact ( = 1)

DV = Degree of Vulnerability (Minority Ranking X Economic Ranking)
Minority Representation Ranking (1 - 5)
Economic Status Ranking (1 - 5)

therefore:

EJ index = [Population Ranking] X [Minority Ranking X Economic Ranking]

[ POP (0 - 4) ] X [ (1 - 5) X (1 - 5 ) ]

Because all HRI subfactors are mathematically related, data from smaller analysis (i.e., environmental justice, enforcement targeting) are directly applicable to formal HRI risk evaluations. Therefore, all special application studies contribute to an ever larger risk analysis. Use of the HRI formula assures the investigator that risk data is evaluated by documented, consistent, peer reviewed ranking criteria.

B. Methodology and Computer System Overview

The Environmental Justice Analysis System (EJ) is resident on the Region 6 EPA Geographic Information System (GIS) and uses other systems (i.e., RCRIS, CERCLIS, TRI, PCS) supported by the Region's Novel LAN to provide locational information to GIS. All Region 6 Programs can perform site specific environmental justice demographic analyses. **The Programs are responsible for the locational accuracy of the data submitted to the computer system and accurate communication or environmental justice findings.**

A one and fifty square mile study area is analyzed around each EJ point location. The computer system clips a circular coverage with a 4 mile radius (50 square miles) from the Census TIGER coverages[3]. Data is extracted from various Census files to address methodology criteria. The EJ index is calculated by finding the percentages for each subfactor for the 50 square mile area, ranking the percentages based on scaling criteria, and multiplying the rankings. The same process is performed for the one square mile analysis (approximate 0.56 mile radius).

**The Environmental Justice Index calculated from these subfactors, or the**

**independent subfactors comprising the Environmental Justice Index, should be used as a *Demographic Correlation Variable* for studies conducted by Programs. These studies serve to evaluate Agency policies or procedures regarding sociological equity. EPA activities for evaluation can include enforcement targets, permit decisions, grant awards, or risk calculations.**

1. Calculation of the Degree of Vulnerability

**Degree of Vulnerability (DV)** for the HRI[2] is the mean of ranking values of demographic data for the minority, economic status, age, pregnancy, life-style factors, and pre-existing disease subfactors (see Chapter I).

Of the subfactors above, minority representation and economic status (household income) are used in the EJ formula. Each DV-EJ subfactor has a scaling range from 1 to 5. **The HRI-Justice vulnerability scaling scores are multiplied.** Therefore, the maximum value for Degree of Vulnerability in the EJ formula is 25.

The scaling criteria for the Degree of Vulnerability subfactors (percent minority and percent economically stressed) are derived from the HRI Degree of Vulnerability Ranking Methodology. Like the HRI, subfactors for the fifty and one mile study areas (EJ communities) are compared to the state in which it resides. Region 6 state EJ criteria (1990 Census) are:

| State | % Minority | % Economically stressed |
|---|---|---|
| Texas | 39.4 % | 27.6 % |
| Louisiana | 34.2 % | 36.3 % |
| Arkansas | 17.7 % | 36.0 % |
| Oklahoma | 19.0 % | 32.0 % |
| New Mexico | 49.0 % | 31.0 % |

The evaluation criteria for the Degree of Vulnerability subfactors is:

| HRI Degree of Vulnerability Ranking Methodology | |
|---|---|
| Criteria | Score |
| Percentage of residents in the risk group is less than or equal to the state % . | 1 |
| Percentage of residents in the risk group greater than the state percentage but less than or equal to 1.33 times the state percentage | 2 |
| Percentage of residents in the risk group greater than 1.33 times the state percentage but less than or equal to 1.66 times the state percentage | 3 |
| Percentage of residents in the risk group greater than 1.66 times the state percentage but less than or equal to 1.99 times the state percentage | 4 |

| Percentage of residents in the risk group greater than or equal to 2 times the state percentage | 5 |
|---|---|

a. The Minority Status Variable - DVMAV (DV-Minority Average)

The Ethnicity (DVMAV) subfactor is derived from a comparison of the area's percent of minority population to the calculated state percent minority population. For example, the average minority percentage in Texas is 39.4 %. The EJ methodology scaling criteria for Texas is:

| MINORITY STATUS VARIABLE | |
|---|---|
| Percent (%) Minority Representation | Score |
| ≤ 39.4 % ( ≤ Texas state average) | 1 |
| > 39.4 % and ≤ 52.4 % | 2 |
| > 52.4 % and ≤ 65.4 % | 3 |
| > 65.4 % and ≤ 78.8 % | 4 |
| > 78.8 % | 5 |

Region 6 chose to include the Hispanic population in the definition of minority, even though this populous may have reported themselves as white in the 1990 Census. The minority population of a Region 6 community is defined as the Census 1990 total of the non-white population plus the white Hispanic-Origin population.

The data used to calculate the minority percentage is found in the block level file called P.L.94-171 of the 1990 Census[3]. The field used is P004_0002 which is defined as White with **no** Hispanic-Origin. This value is subtracted from the total population, giving the number of people who are Non-White or White with Hispanic-Origin. The percentage of people in the study area that are Non-White or White with Hispanic-Origin is compared to the State percentage of people in this same census category. Detailed documentation of the state census numbers used and methodology calculations is found in the EJ Computer System User's Guide (Potential Environmental Justice Index)[4].

b. The Economic Status Variable - DVECO (DV-Economic Status)

The Economic Status (DVECO) subfactor is derived from a comparison of the area's percent economically stressed to the calculated state percent economically stressed population. Census household income data is block group level data. The block group scaling score is used for each census block in the HRI-Justice calculation when finding the EJ index for a

block. For the Economic Status subfactor, the risk group is assumed to be households that make less than $15,000 a year. For example, in Texas the percentage of such households is 27.6 %. The economic status scaling criteria for Texas is:

| ECONOMIC STATUS VARIABLE | |
|---|---|
| Percent (%) Households below $ 15 K | Score |
| ≤ 27.6 % ( ≤ Texas state average) | 1 |
| > 27.6 % and ≤ 36.7 % | 2 |
| > 36.7 % and ≤ 45.8 % | 3 |
| > 45.8 % and ≤ 55.2 % | 4 |
| > 55.2 % | 5 |

The data used to calculate the economically stressed percentage is found in STF3A of the 1990 Census[3], specifically the files STF301 and STF314. The economic data found in the P80 category of STF314 is reported by household, therefore, to find the percentage of economically stressed it is necessary to use the number of households from P5 field (P0050001) of STF301 as a denominator. The fields used to total the low income group are the sum of P0800001, P0800002, P0800003, and P0800004 of STF314. Detailed documentation of the state census numbers used and methodology calculations is found in the EJ Computer System User's Guide[4].

2. Calculation of Population Factor

The **Population Factor (POP)** used in the justice formula is the population density score for the study area. The population density ranking (POP) is determined by evaluating the total population from POP100 of PL94171, and evaluating the average one square mile population for the area. The density is ranked by the scaling criteria following. The criteria scores range from 0 to 4.

| POPULATION FACTOR Density Ranking | |
|---|---|
| Population per Sq. Mile | Scaling Score |
| 0 | 0 |
| > 0 and ≤ 200 | 1 |
| > 200 and ≤ 1,000 | 2 |
| > 1,000 and ≤ 5,000 | 3 |
| > 5,000 | 4 |

The population is found for the study area and ranked on a one square mile area.

3. Calculation of the Potential Environmental Justice Index

The product of the subfactors, Minority Status (DVMAV), Economic Status (DVECO), and Population Factor (POP) is the Potential Environmental Justice Index (EJ). The maximum possible value of the EJ index is 100.

C. System Features

1. The User's Guide

A Region 6 EJ Computer System User's Guide[4] is available (Potential Environmental Justice Index). The guide presents the computer screens experienced by users through the menu activity as well as general GIS lessons on using the Data General interface with UNIX for support of Environmental Justice data processing.

*Quality Assured Locational Data*
*THE MOST IMPORTANT STEP OF GEOGRAPHIC INFORMATION SYSTEM APPLICATIONS IS THE PROCESSES THAT ASSURE THE LOCATIONAL DATA USED IS ACCURATE.*

*THE ACCURACY OF THE DATA IS THE REQUESTING PROGRAM'S RESPONSIBILITY.*

Before anyone evokes the Environmental Justice System, consideration for Quality Assured Locational Data must be made. The system tracks the Quality Assurance of the location, the Requestor's name and Program-Code.

2. Input

There are two methods of input currently available for the EJ system, individual site processing and batch processing. Both use Latitude and Longitude location for conversion to GIS-albers coordinates (X-axis, Y-axis). Programs and primary data gathering groups use Latitude and Longitude as the standard method of identifying location, therefore, this system is designed to address this data format.

The EJ system employs an interactive menu interface to evoke the proper method of input. The Individual Site Processing Option prompts the user for information that meet the output criteria where the system cannot answer the query. The Batch Processing Option prompts the user for a file name where dBase data has been stored.

The user is responsible for input for:
Name of the Requestor
Source of Quality Assured Locational Data
Latitude/Longitude
EPA Identifying number and Site Name
Mail Code

Users collect data from the EPA Mainframe systems or through program file research and are responsible for the accuracy of the information. If the need exists to evaluate more than 1 location, a dBase file can be built by the user to transfer the batch of locations to GIS. The EJ System will automatically convert the dBase file into a format compatible with the Region 6 GIS system. The user is given the steps to complete the task through the User's Guide on How to Transfer dBase Files to GIS.

D. Examples of Region 6 Environmental Justice Analyses

1. Enforcement Targeting

One of the many applications for environmental justice evaluations is enforcement targeting. This is a procedure which ranks industrial facilities as to the potential impact each site may pose to human health and the environment. Region 6 typically identifies facilities that have

been non-compliant in more than one media program (Air, NPDES, RCRA). These facilities are subjected to a computerized risk screening methodology using census information and Toxic Release Inventory (TRI) data. These facilities are also evaluated by the Environmental Justice computer methodology. Each site can be ranked by potential risk, environmental justice ranking, population around each site, economic status of surrounding communities, or by minority representation for the one and fifty square mile study areas. Facilities which score high in historical noncompliance, risk, and environmental justice are potential priority enforcement targets. A four mile radius was demographically evaluated for each industrial facility and ranked from 0 to 100.

2. Permitting for Industrial Sites

A major responsibility of EPA and State environmental agencies is the permitting of industry related activities which impact the environment. The Region's EJ formula is used to accurately access demographic information for one and fifty square mile areas around sites being considered for permit privileges. The following examples are for individual sites, but the EJ system is also used to evaluate permitting practices for whole regulatory programs (i.e., RCRA, NPDES, MSW) involving hundreds of sites. Table IV.1 shows the EJ analysis findings for four permitted sites described below and Houston Scrap in Houston, Texas.

a. Environmental Impact Statement - Wallace, Louisiana

A plastics manufacturing facility asked regulators for a permit to build a plant near Wallace, Louisiana, on the west bank of the Mississippi river (the lower half of Maps 1 - 3). EPA Environmental Impact Statements do not traditionally assess environmental justice issues. The EJ formula was used to characterize the demographics of the community around the proposed site. The site of interest is approximately in the center of each map. Map 1 shows the minority ranking of each block, Map 2 the economic status for census block group, and Map 3 demonstrates EJ index values for each census block. The data indicates that one square mile around the site is sparsely populated (133 residents), one-hundred percent minority, and economically stressed. The plastics facility did not build in this area. The EJ analysis was used as an Regional awareness tool.

b. Underground Injection Well Permit Application - Winona, Texas (Gibraltar Well # 186)

A company in the deep piney woods of East Texas applied for a permit to continue injecting hazardous waste underground. A segment of the small community town of Winona, Texas opposed the facility operation and the issuance of a permit. Maps 4- 6 show the demographics surrounding the facility. There are few residents near the injection well (0.56 mile radius from site). This does not indicate a lack of potential EJ concern. Program managers are responsible for accessing demographic information and determinating possible EJ concern.

c. Wastewater Treatment Plant - Marrero, Louisiana

Conditions of an NPDES permit were evaluated for a wastewater treatment plant in Southern Louisiana near New Orleans. EJ

demographic information was used by EPA staff for a public meeting. The information is shown in Maps 7 - 9.

d. Uranium Processing Facility - Gore, Oklahoma

Sequoyah Fuels is a uranium processing facility on the banks of the Arkansas and Illinois Rivers in Eastern Oklahoma. The company has several permits from EPA and DOE. A Native American environmental group has opposed the facility's operation and requested an EJ analysis. Notice the zero population reported for the 1 square mile study area. The EJ analysis does not evaluate worker populations. The facility borders land owned by Native Americans. Maps 10 - 12.

3. Superfund

a. In 1991 areas of West Dallas were found to contain varying levels of lead contaminated soil. One source of the pollution had been the RSR Smelter. Region 6 EPA and the Texas Natural Resource Conservation Commission (TNRCC) are removing contaminated soils from the Dallas community. A component of the risk management plan was an evaluation of communities adjacent to permitted hazardous waste facilities being considered to receive the West Dallas soil. The soil was <u>not</u> hazardous. A proposed landfill in Avalon, Texas was evaluated using the Environmental Justice methodology.

1). Waste Disposal Site and West Dallas EJ Analyses

**Avalon, TX** is a small rural community about fifty miles south of Dallas. CSC Disposal is a hazardous waste site in the city. The Minority Status, Economic Status, and Population Factor of the Region 6 EJ methodology were calculated for the community around the landfill site. Maps 13 - 15 demonstrate the 1 and 50 square mile EJ analyses for the Avalon, CSC facility. An analysis of the West Dallas site is also presented in Maps 16 - 18.

Other waste disposal facilities were considered for the disposal of West Dallas soil. Two of these sites were landfills near Conroe, Texas and Monroe, Louisiana.

2) Results

Demographic information produced by the EJ methodology characterized each waste site considered for landfill disposal of West Dallas soil. The environmental justice information was combined with transportation distance, transport safety, facility design, and cost considerations to decide which landfill was the best overall disposal site choice. The Avalon site was selected. The non-contaminated soil was transported and deposited at this regulated site in 1993-94.

b. Emergency Response - Houston Scrap, Harris County, Texas

Houston Scrap is a battery cracker, collecting lead from used auto batteries for recycling. Lead concentrations on site in excess of thirty percent have been measured, offsite contamination is known to exist, but the full extent has not been identified. The company has been ordered to immediately remome contaminated waste piles. Emergency response has fenced the area to keep the public out.

Remedial activities are anticipated once the surficial waste piles are removed. Maps 19 - 21.

E. Discussion

1. Environmental Justice Index scores are a general ranking tool. Population density, percent minority population, and percent of economically depressed household data are the more important analytical factors. When evaluated independently, they often provide greater insight to the potential environmental justice concerns and can be used alone to rank sites (i.e., sites ranked on percent minority or economic status, or the combination of these two factors). **The methodology user should realize that even an index ranking of zero can have significant EJ concerns**. For example, an unpopulated study area will rank a zero, but the land can be owned by or adjacent to land owned by minority and/or low income groups. The uranium processing plant bordering Native American land in Gore, Oklahoma is such a site (Maps 10 - 12).

2. **The Region does not believe an environmental health risk must exist before there can be justice concerns. This is evident by the absence of risk criteria from the EJ methodology.** An analysis of an area's potential risk from chemical releases is calculated at a default value of 1. Region 6 has an automated risk methodology developed independent of EJ analysis. Both justice and risk evaluations are used for enforcement targeting projects.

3. Environmental justice has great potential to be misunderstood by government and the public. Application of the basic principles of science can help prevent this misunderstanding. An accurate assessment of demographic data will compliment our community outreach and environmental justice awareness efforts.

4. The EJ Index is derived from the product of three criteria factors with values ranging from 0 - 4, 1 - 5, and 1 - 5. The index can range from 0 - 100, but, mathematically, there are not 100 index values possible. This should be remembered when using the methodology for enforcement targeting and other multi-site applications. The range of possible values is smaller for facilities ranking between 50 and 100 than for those ranking from 1 to 49. Therefore, there can be a greater demographic difference between two facilities ranking 60 than for two sites ranking 20.

5. Methodology users should realize that if ranking factors for minority and economic status are both ranked "5", and the site is in a relatively low population area, the highest possible EJ Index is only 25 (on a scale from 0 to 100). Therefore, higher rankings require high population areas. The computer code describing the spacial and mathematical aspects of the methodology is documented in the Pilot Degree of Vulnerability and Potential Environmental Justice Index System Documentation[5].

6. Although the subfactors are similarly weighted, it is possible that population may have been an "indicator" factor. Meaning, wherever population density is high, the other subfactors tend to rank high. Urbanization may be a concern in this regard. Statistical analyses are planned to further study this possibility.

7. Environmental justice criteria rankings can be very different when the

50 square mile area is compared to the 1 square mile evaluation. Subfactor differences are caused by a change in the number of census blocks analyzed and the actual demographics for the individual blocks. When the study area boundry (line for the 0.56 mile or the 4 mile radius) crosses through a census block, the population is assumed to be equaly distributed through the block's area. Therefore, if a block with 1000 residents is halved, a population of 500 is counted for that block. This process can potentially cause significant error depending on the number of blocks and the degree of population segregation within each block.

8. Although EJ studies can be statistically analyzed using standard methods, obtaining statistical significance for study areas with few census blocks is more difficult than for larger areas. Several of the one mile study areas had less than 30 census blocks. Avalon, Texas has 14 and not all of those were complete (totally within the study area).

# TABLE IV.1
## Environmental Justice - Permitting Industrial Sites

| Location | Population (Ranking) | Minority Percentage (Ranking) | Economic Percentage (Ranking) | EJ Ranking Index Value |
|---|---|---|---|---|
| Wallace, LA | 6,436 | 67.5 % | 41.8 % | |
| (50 sq.mi.) | (1) | (4) | (2) | 8 |
| Wallace, LA | 133 | 100.0 % | 39.3 % | |
| (1 sq.mi.) | (1) | (5) | (2) | 10 |
| Winona, TX | 2,060 | 26.0 % | 31.4 % | |
| (50 sq.mi) | (1) | (1) | (2) | 2 |
| Winona, TX | 16 | 12.5 % | 27.1 % | |
| (1 sq.mi.) | (1) | (1) | (1) | 1 |
| Gore, OK | 1,973 | 21.7 % | 47.8 % | |
| (50 sq.mi.) | (1) | (2) | (3) | 6 |
| Gore, OK | 0 | 0 % | 0 % | |
| (1 sq.mi.) | (0) | (1) | (1) | 0 |
| Dallas, TX | 137,276 | 73/4 % | 38.5 % | |
| (50 sq.mi.) | (3) | (4) | (3) | 36 |
| Dallas, TX | 1,616 | 99.4 % | 69.8 % | |
| (1 sq.mi.) | (3) | (5) | (5) | 75 |

| | | | | |
|---|---|---|---|---|
| Houston, TX | 206,442 | 84.8 % | 48.1 % | |
| (50 sq.mi.) | (3) | (5) | (4) | 60 |
| Houston, TX | 3,953 | 92.2 % | 54.5 % | |
| (1 sq.mi.) | (3) | (5) | (4) | 60 |

# References


1. U.S. EPA. Environmental Equity: Reducing Risk for All Communities, Policy, Planning, and Evaluation (PM-221), EPA230-R-92-008, June 1992

2. U.S. EPA. Region 6 Human Health Risk Index Draft Document, Policy and Analysis Section, Dallas, TX, January 1991.

3. U.S. Census Bureau, TIGER STF3A Census Coverage, P.L. 94-171, P004_0002.

4. U.S. EPA. Region 6 Pilot Potential Environmental Justice Index: User's Guide, Dallas, TX, April 1994

5. U.S. EPA. Region 6 Degree of Vulnerability and Potential Environmental Justice Index System Documentation, Dallas, TX, September 1993